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(54) **NOISE SUPPRESSION STRUCTURE**

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H05K 5/02 (2006.01)

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(58) **Field of Classification Search** 181/199, 181/150, 151; 381/391, 86, 333, 388, 389, 381/189, 301, 302
See application file for complete search history.

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(57) **ABSTRACT**

In a noise suppression structure of the present invention, a sound absorption sheet is pinched between a flange of a speaker grille and an interior trim. An opening of a space formed by the flange of the speaker grille and a sound guiding tube is covered with the sound absorption sheet.

3 Claims, 4 Drawing Sheets

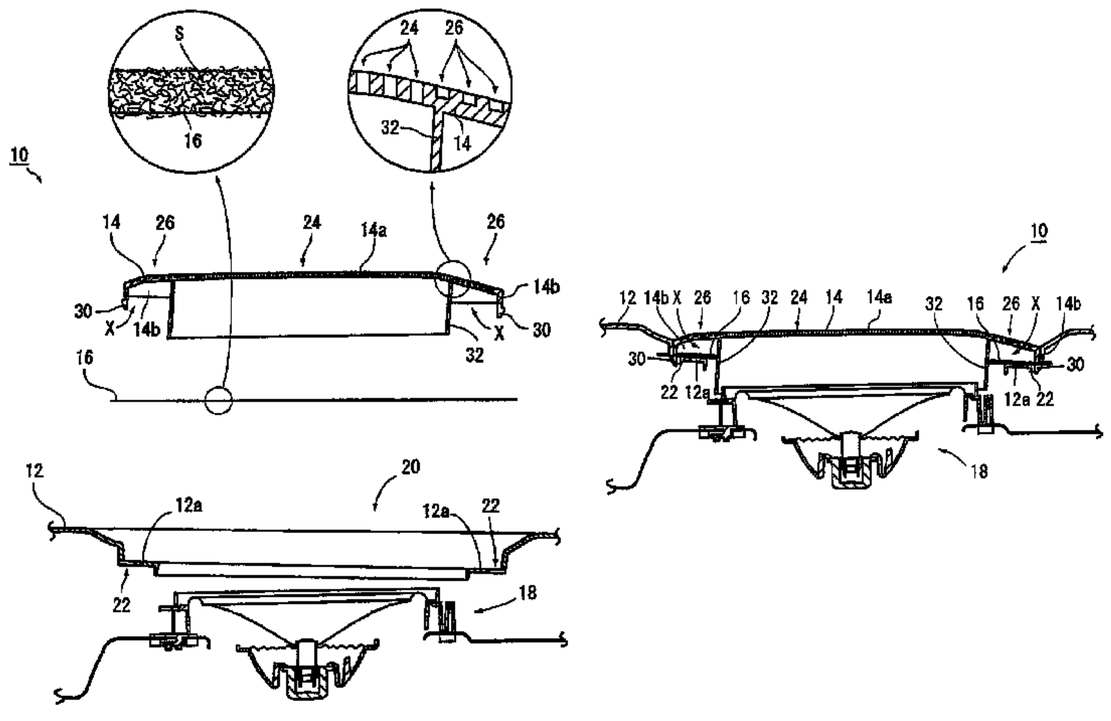

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FIG.1

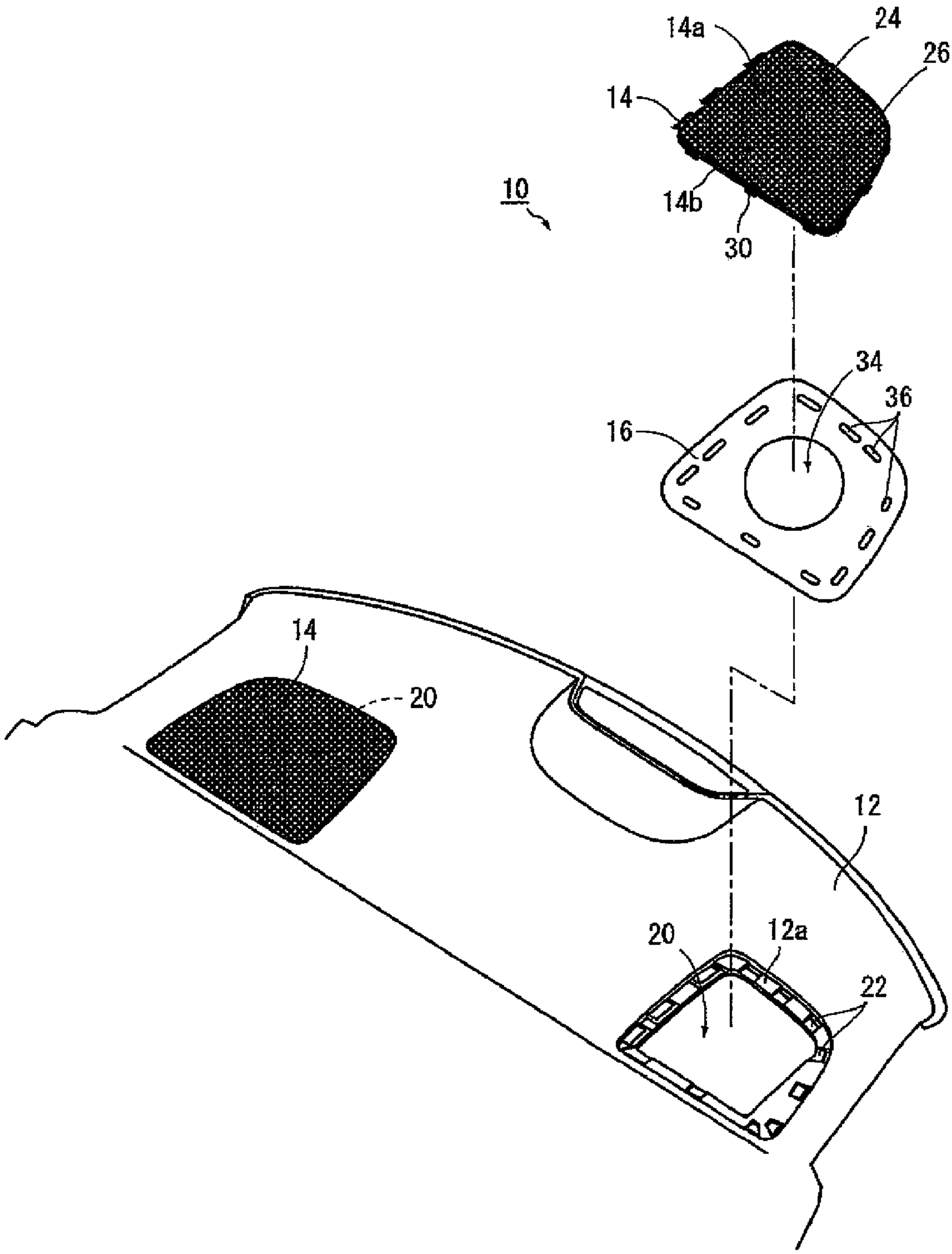
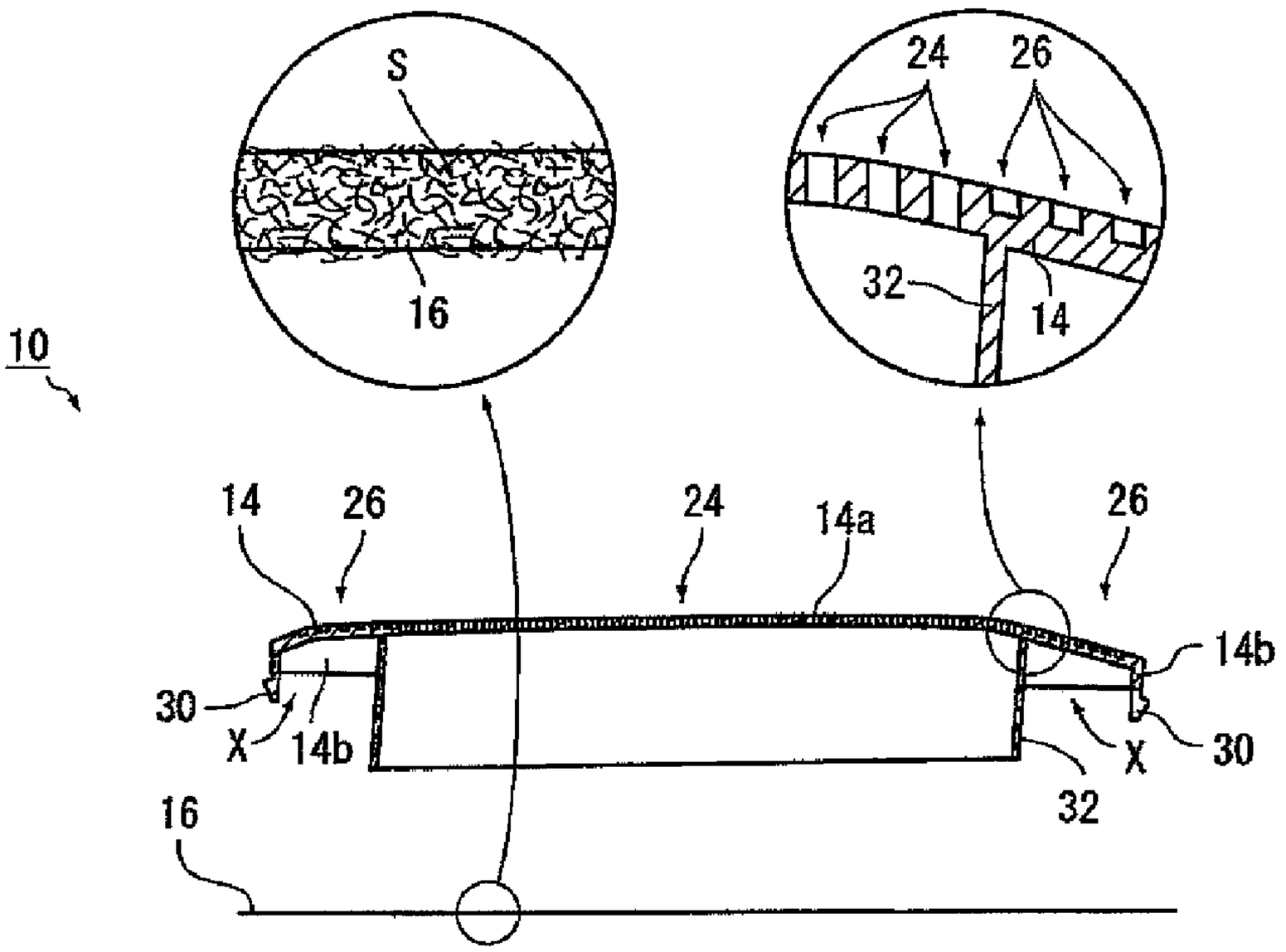


FIG.2


S
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14a
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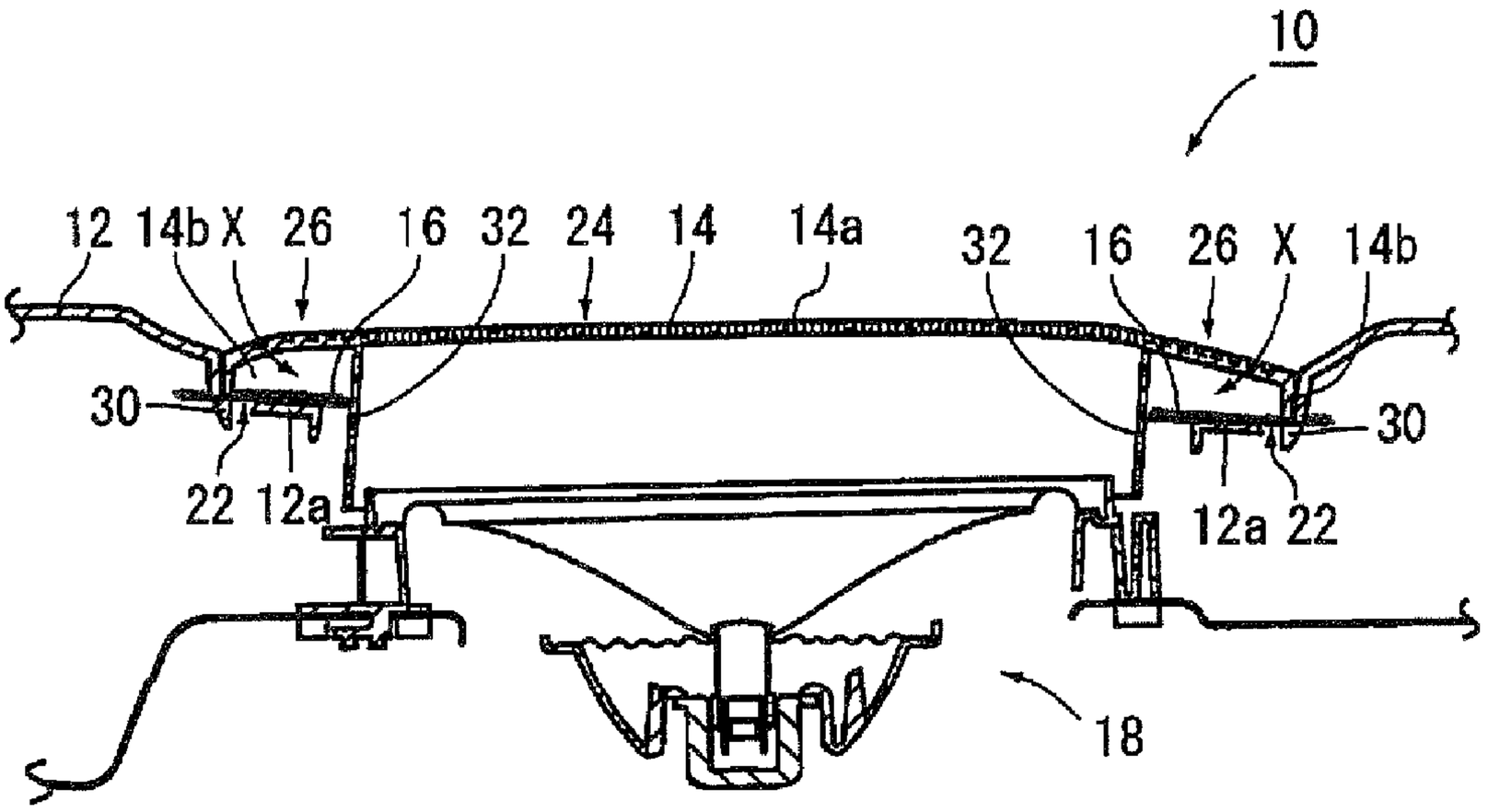
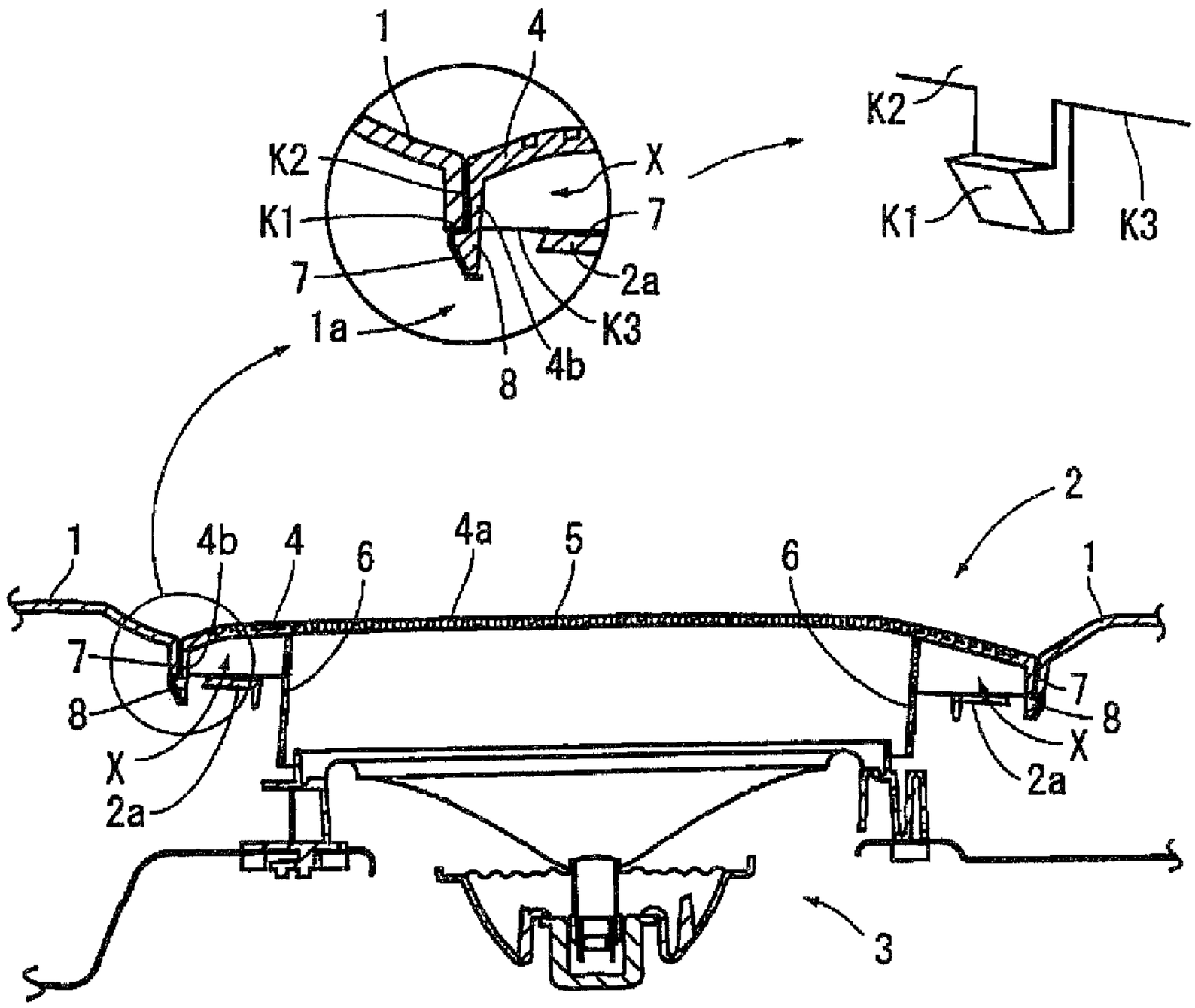
18

FIG.3



(PRIOR ART)

FIG.4



NOISE SUPPRESSION STRUCTURE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a noise suppression structure for preventing noise such as friction sound and reverberation caused when sound from a speaker vibrates a speaker grille.

2. Background Art

For placing a speaker of a vehicle audio system in an interior of a vehicle (e.g. a car), a recess **2***a* for fitting a speaker grille **4** is formed in a position corresponding to a speaker opening **2** in an interior trim **1** (the position where the speaker grille **4** is attached), as shown in FIG. **4**. The speaker opening **2** is opened in the recess **2***a*, and a speaker **3** is disposed in the speaker opening **2**. The speaker grille **4** is fitted in the recess **2***a* so as to cover the speaker opening **2**.

The speaker grille **4** is provided to protect the speaker **3** from an external shock and improve the appearance. The sound from the speaker **3** passes through sound holes **5** which are formed in a ceiling board **4***a* of the speaker grille **4**. A flange **4***b* is formed in the periphery of the ceiling board **4***a* of the speaker grille **4**. The speaker grille **4** can be detachably attached to the interior trim **1** by engaging hooks **8** provided at the end of the flange **4***b* with engaging holes la opened in the interior trim **1**. A cylindrical-shaped sound guiding tube **6** for carrying sound from the speaker **3** to the sound holes **5** efficiently is extended downward from the ceiling board **4***a* of the speaker grille **4**. The speaker grille **4** is detachably attached to the interior trim **1** for maintenance of the speaker **3**.

The sound from the speaker **3** passes through the sound guiding tube **6** and the sound holes **5** of the speaker grille **4** and reaches the ears of a passenger.

The sound from the speaker **3** also vibrates the speaker grille **4**. In the structure where the speaker grille **4** is detachably attached to the interior trim **1**, when the speaker grille **4** vibrates, friction sound may be generated at contact parts between the speaker grille **4** and the interior trim **1** (specifically, each of retaining pars K**1** between the engaging holes **1***a* and the hooks, contact part between an outer face K**2** of the flange **4***b* and the interior trim **1** and contact part between a lower edge K**3** of the flange **4***b* and the interior trim **1**). And the friction sound is a noise offensive to the ear.

To address the problem, conventionally, non-woven fabric **7** is adhered to the contact parts of the speaker grille **4**, the retaining part K**1**, the outer face K**2** of the flange **4***b*, and the lower edge K**3**. Generally, adhesive material is provided on the back side of the non-woven fabric **7**. With the adhesive material, the non-woven fabric **7** is adhered to the speaker grille **4**).

As described above, adhesion of the non-woven fabric **7** to the parts K**1** to K**3** contacting with the interior trim **1** of the speaker grille **4**, friction sound is generated between the speaker grille **4** and the interior trim **1**.

However, adhesion of the non-woven fabric **7** piece by piece to the contact parts K**1** to K**3** is too complicated to be automated easily. Consequently, the non-woven fabric **7** is conventionally manually adhered. Such the manual work is very time consuming and inefficient which results in a variability in quality by workers.

In addition, there is the case that the adhesive material provided on the back side of the non-woven fabric **7** contains a hazardous material such as VOC (Volatile Organic Compound). When the hazardous material diffuses in a small vehicle compartment, it may be harmful to the health of a passenger.

Further, even when the generation of the friction sound is suppressed with adhering the non-woven fabric **7**, a new problem arises such that another type of noise which had been hidden by the friction sound. Specifically, when the speaker grille **4** vibrates, the vibration sound generated at this time reverberates in a space X formed between the flange **4***b* and the sound guiding tube **6** of the speaker grille **4**, and the reverberation becomes the new problem.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a noise suppression structure which can be easily and reliably assembled, eliminating the influence of hazardous material such as VOC and, moreover, preventing noise such as frictional sound and reverberation due to vibration of a speaker grille.

According to a first aspect of the present invention, a noise suppression structure **10** has;

an interior trim **12** having an opening for speaker **20** and engaging holes **22** opened around the opening for speaker **20**;

a speaker **18** facing the opening for speaker **20**;

a speaker grille **14** attached to the interior trim **12** so as to close the speaker opening **20**, including a ceiling board **14***a* having sound holes **24** allowing passage of sound from the speaker **18**, a flange **14***b* extended downward from outer periphery of the ceiling board **14***a*, a sound guiding tube **32** extended downward from the ceiling board **14***a* so as to surround the speaker **18**, and hooks **30** that engage with the engaging holes **22**; and

a sound absorption sheet **16** pinched between the flange **14***b* of the speaker grille **14** and the interior trim **12** except portions between the hooks **30** and the engage holes **22**, having a sound guiding tube insertion hole **34** allowing insertion of the sound guiding tube **32**, and covering an opening of a space X formed with the flange **14***b* and the sound guiding tube **32**.

In the present invention, the sound absorption sheet **16** is pinched between the flange **14***b* of the speaker grille **14** and the interior trim **12**. Consequently, even when the speaker grille **14** vibrates with the sound from the speaker **18**, the vibration is absorbed by the sound absorption sheet **16** at the pinched portion, and no friction noise is generated. On the other hand, in the portion other than the flange **14***b* of the speaker grille **14**, the hooks **30** are engaged/contacted directly with the engaging holes **22**. However, since there are no allowances in each of the engagement portions between the hooks **30** and the engaging holes **22** by pinching the sound absorption sheet **16** with sufficient elasticity. Consequently, the generation of friction sound at these portions is largely reduced. In addition, the sound absorption sheet **16** contacts with the speaker grille **14** around the hooks **30** and is pinched between the speaker grille **14** and the interior trim **12**. The friction sound which generated even slightly is absorbed by the sound absorption sheet **16** and is reduced to inaudible sound.

Reverberation transmitted to the space X between the flange **14***b* of the speaker grille **14** and the sound guiding tube **32** (i.e. vibration sound generated by vibrating the speaker grille **14** and transmitted into the space X) is efficiently absorbed with the sound absorption sheet **16** covering the opening of the space X. Consequently, reverberation which causes another type of noise is not generated in the space X.

Further, the noise suppression structure **10** can be reliably assembled with the simple work that covering the opening in the space X between the flange **14***b* of the speaker grille **14** and the sound guiding tube **32** with the sound absorption sheet

16 and attaching the speaker grille **14** in which the opening in the space X is covered with the sound absorption sheet **16** to the interior trim **12**. When assembling the noise suppression structure **10**, work variations among workers do not occur. Moreover, the adhesive material conventionally used for attaching the sound absorption sheet **16** is not necessary. Thus, unlike the conventional technique, hazardous materials such as VOC are not diffused in a vehicle compartment.

The sound absorption sheet **16** may be made of woven fabric or non-woven fabric.

A number of voids S exist within the non-woven fabric or woven fabric, and the sound absorption effect with the voids S can be obtained. That is, when vibration sound generated by vibrating the speaker grille **14** and transmitted into the space X reaches to the sound absorption sheet **16**, the vibration sound is converted to heat energy by "frictional resistance in the void S" and "resonance in the void S", and absorbed.

The noise suppression structure which can be easily and reliably assembled, eliminate the influence of a hazardous material such as VOC and, moreover, prevent generation of noise such as friction sound and reverberation generated by vibration of the speaker grille can be obtained.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for purpose of illustration only and is not intended as a definition of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view showing noise suppression structure for a speaker as an embodiment of the invention.

FIG. **2** is an exploded cross section showing the noise suppression structure for a speaker as the embodiment of the invention.

FIG. **3** is a cross section of the noise suppression structure for a speaker as the embodiment of the invention.

FIG. **4** is a cross section showing a conventional noise suppression structure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The noise suppression structure **10** is to prevent noise offensive to the ear such as friction sound and reverberation caused when sound from a speaker vibrates a speaker grille **14**. As shown in FIGS. **1** and **2**, the noise suppression structure **10** is constructed by an interior trim **12** of a vehicle, a speaker grille **14**, a sound absorption sheet **16**, and a speaker **18**.

The interior trim **12** is a resin board constructing an interior surface of a vehicle. The outline of the interior trim **12** is formed in accordance with the shape of a rear part of a back seat. Speaker openings **20** are formed on both sides of the interior trim **12**. The inner shape of the speaker opening **20** is formed in an almost square shape, but may be a circle shape or a triangle shape.

The edge of the speaker opening **20** in the interior trim **12** is formed in a step pattern. A plurality of engaging holes **22** (twelve holes in the embodiment) are formed in the step part of the speaker opening **20**, that is, around a recess **12***a*.

The speaker grille **14** is provided to protect the speaker **18** from an external shock and to improve the appearance. The speaker grille **14** has a ceiling board **14***a*, a flange **14***b* extended downward from the entire outer periphery of the ceiling board **14***a*, and a sound guiding tube **32** having a cylindrical shape (the shape may be a cylinder, a rectangular cylinder, an elliptical cylinder, or the like), which are formed integrally. The speaker grille **14** is injection-molded using a synthetic resin, for example: PP (polypropylene); PE (polyethylene); PET (polyethylene terephthalate); PBT (polybutylene terephthalate); PVC (polyvinyl chloride); or ABS resin.

A plurality of sound holes **24** which allow passages of the sound from the speaker **18** are formed at the ceiling board **14***a* of the speaker grille **14** within the sound guiding tube **32** corresponding to the speaker **18**. At the ceiling board **14***a* of the speaker grille **14** outside of the sound guiding tube **32**, that is, around the area where the sound holes **24** are formed, a plurality of decorative blind holes **26** (or through holes) each having an inside diameter almost equal to that of the sound hole **24** are formed. Then, a visual effect can be produced as if the sound holes **24** are formed in the entire ceiling board **14***a* of the speaker grille **14**.

As described above, the sound guiding tube **32** for carrying sound efficiently from the speaker **18** is extended downward from the ceiling board **14***a* of the speaker grille **14** so as to surround the sound holes **24**. The height of the sound guiding tube **32** is properly set so that the lower end of the sound guiding tube **32** is positioned near the speaker **18** so as to surround the speaker **18** when the speaker grille **14** is attached to the interior trim **12** (refer to FIG. **3**).

A plurality of hooks **30** (twelve hooks in the embodiment, so as to match the number of engaging holes **22**) to be engaged with the corresponding engaging holes **22** in the interior trim **12** are extended downward from the speaker grille **14**. In the embodiment, each of the hooks **30** is extended downward integrally from the flange **14***b* of the speaker grille **14**. The shape of the speaker grille **14** (the outer periphery of the flange **14***b*) is formed in accordance with the shape of the recess **12***a* as a step part of the interior trim **12**.

The sound absorption sheet **16** is made of non-woven fabric. The size of the sound absorption sheet **16** is set to be larger than that of the speaker grille **14** so as to be able to cover the space X formed by the flange **14***b* of the speaker grille **14** and the sound guiding tube **32**. At the center of the sound absorption sheet **16**, a sound guiding tube insertion hole **34** (refer to FIG. **1**) is formed at a position corresponding to the sound guiding tube **32** of the speaker grille **14**. At outer periphery of the sound absorption sheet **16**, a plurality of hooks insertion holes **36** (in the embodiment, twelve hook insertion holes **36** so as to match the number of hooks **30**) for inserting the hooks **30** are formed at positions corresponding to the hooks **30**.

Preferably, the thickness of the sound absorption sheet **16** is set in the range of 0.5 to 1.0 mm in consideration of the strength and the allowance between the speaker grille **14** and the interior trim **12** for attaching (in the embodiment, the thickness of the sound absorption sheet **16** is set to 0.5 mm).

The reason that the lower limit of the thickness of the sound absorption sheet **16** is set to 0.5 mm is to keep the strength of the sound absorption sheet **16** itself retaining. On the other hand, the reason that the upper limit of the thickness of the sound absorption sheet **16** is set to 1.0 mm is to keep the allowance between the speaker grille **14** and the interior trim **12** for attaching the speaker grille **14** to the interior trim **12**.

The reason for selecting no-woven fabric as the material of the sound absorption sheet **16** is that innumerable fine openings are opened in the surface of non-woven fabric and communicate with a number of "voids S" in that. Vibration generated from the speaker grille **14** and transmitted to the sound absorption sheet **16** is converted to heat energy by "frictional resistance in the void S" and "resonance in the void S" and efficiently absorbed.

The material of the sound absorption sheet **16**, therefore, is not limited to non-woven fabric but any material can be used as long as it has a number of "voids" in that and has the sound absorption effect produced by the "voids". For example, woven fabric or a resin foamed sheet having interconnecting cells or closed cells (in such case, innumerable fine openings are not formed in the surface but a number of "voids" exist on the inside of a surface layer and have the sound absorption effect) can be used as the sound absorption sheet **16**.

For assembling the noise suppression structure **10**, first, the hooks **30** of the speaker grille **14** is inserted into the hook insertion holes **36** in the sound absorption sheet **16**. Then the sound guiding tube **32** of the speaker grille **14** is fitted in the sound guiding tube insertion hole **34** in the sound absorption sheet **16**, and the attachment of the sound absorption sheet **16** to the speaker grille **14** is completed. The sound guiding tube insertion hole **34** in the sound absorption sheet **16** is not fixed to the speaker grille **14** but is free. When the sound absorption sheet **16** is attached to the speaker grille **14**, the space X formed by the flange **14***b* of the speaker grille **14** and the sound guiding tube **32** is covered with the sound absorption sheet **16**.

The hooks **30** of the speaker grille **14** inserted into the hook insertion holes **36** in the sound absorption sheet **16** are engaged with the engaging holes **22** formed in the recess **12***a* of the interior trim **12**. The flange **14***b* of the speaker grille **14** is fitted in the recess **12***a* as the step part in the interior trim **12**, and the sound absorption sheet **16** is pinched between the flange **14***b* of the speaker grille **14** and the interior trim **12** in a portion other than the hook **30**, thereby completing assembly of the noise suppression structure **10**.

The speaker grille **14** is vibrated with the sound. The sound absorption sheet **16** is pinched between the portion other than the hook **30** of the speaker grille **14** (the flange **14***b*) and the interior trim **12**. In other words, the speaker grille **14** and the interior trim **12** are not in direct contact with each other. Even if the speaker grille **14** vibrates, therefore, friction noise is not generated between the flange **14***b* and the interior trim **12**. On the other hand, in the part other than the pinching part of the speaker griller **14**, that is, in the part other than the flange **14***b*, the hook **30** is directly in engagement and contact with the engaging hole **22**. However, there is no allowance in each of the engaging parts between the hooks **30** and the engaging holes **22** by pinching the sound absorption sheet **16** with sufficient elasticity. Consequently, the generation of friction sound at these parts is largely reduced. In addition, as described above, the sound absorption sheet **16** contacts with the speaker grille **14** around the hooks **30** and is pinched between the speaker grille **14** and the interior trim **12**. The friction sound generated even slightly is absorbed by the sound absorption sheet **16** and is reduced to inaudible sound.

Since the opening of the space X formed between the flange **14***b* of the speaker grille **14** and the sound guiding tube **32** is covered with the sound absorption sheet **16**, vibration sound generated by vibration of the speaker grille **14** propagates in the space X and reaches to the sound absorption sheet **16**. The sound absorption sheet **16** is made of non-woven fabric in which innumerable "voids S" exist. The sound reached to the sound absorption sheet **16**, therefore, is converted to heat energy by "frictional resistance in the void S" and "resonance in the void S" and absorbed. Moreover, the sound guiding tube insertion hole **34** in the sound absorption sheet **16** is not fixed but is free. In other words, the sound absorption sheet **16** is a plane sheet which periphery is pinched and having a large hole in its center. The sound absorption sheet **16**, therefore, does not easily resonate with sounds at all frequencies from low to high and effectively absorbs the sounds with the above-described mechanism.

As described above, vibration sound generated by vibration of the speaker grille **14** propagates in the space X and is absorbed by the sound absorption sheet **16**. That means reverberation causing another noise is not generated in the space X.

For assembling the noise suppression structure **10**, it is sufficient to cover the opening of the space X between the flange **14***b* of the speaker grille **14** and the sound guiding tube **32** with the sound absorption sheet **16** and attach the speaker grille **14** in which the opening of the space X is covered with the sound absorption sheet **16** to the interior trim **12**. The assembly is simple and reliable. Consequently, work variations among workers do not occur for assembling the noise suppression structure **10**. Moreover, the adhesive material conventionally used for attaching the sound absorption sheet **16** is not necessary. Thus, hazardous materials such as VOC are not diffused in a vehicle compartment space.

The disclosure of Japanese Patent Application No. 2007-213784 filed Aug. 20, 2007 including specification, drawings and claims is incorporated herein by reference in its entirety.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been changed in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A noise suppression structure comprising:

an interior trim having a speaker opening and engaging holes around the speaker opening;

a speaker facing the speaker opening;

a speaker grill attached to the interior trim so as to close the speaker opening, including a ceiling board having sound holes allowing passage of sound from the speaker, a flange extended downward from outer periphery of the ceiling board, a sound guiding tube extended downward from the ceiling board so as to surround the speaker, and hooks that engage with the engaging holes; and

a sound absorption sheet pinched between the flange of the speaker grill and the interior trim having plurality hook insertion holes at outer periphery for inserting the hooks and a sound guiding tube insertion hole at a central portion allowing insertion of the sound guiding tube, where said sound absorption sheet covers an opening of a space between the flange and the sound guiding tube.

2. The noise suppression structure according to claim **1**, wherein the sound absorption sheet is made of woven fabric or non-woven fabric.

3. The noise suppression structure according to claim **1**, wherein the sound absorption sheet having a thickness in the range of 0.5 to 1.0 mm.

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